

# **Draft minutes of 5th SPIRE Bolometer Array Group Meeting** **Caltech, 20, 21 May 1999**

**Matt Griffin, 24 May 1999**

**Note:**

1. These are draft minutes - please send comments/corrections to Matt Griffin by May 31 for incorporation into the final minutes.
2. These minutes should be read in conjunction with the viewgraph package from the meeting, which contains most of the information - this will be made available shortly.
3. Actions and their due dates are tabulated in Section 13.

## **List of attendees**

Name	Institute	E-mail
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Anthony Turner	JPL	adturner@pop.jpl.nasa.gov
Laurent Vigroux	SAP	vigroux@discovery.saclay.cea.fr
George Voellmer	GSFC	voellmer@gsfc.nasa.gov

# 1 Introduction and aims of the meeting

Matt Griffin presented some introductory viewgraphs on the aims of the meeting and the current status of FIRST and SPIRE. The main aims of the meeting were:

- to prepare for PDR Phase 1 in July;
- to review technical progress on array options since the QMW meeting in January;
- to plan the array test programme for the rest of 1999.

## Status of FIRST:

- The mission and payload were approved by the SPC in February. At its most recent meeting in mid-May, the SPC had reconfirmed the FIRST and Planck programmes with a launch date in early 2007.
- The use of X-band transponders increasingly likely, and the available data rate was expected to be around 200 kbs. While this had not yet been officially confirmed, it would be appropriate to assume this figure for planning and design purposes.
- Terry Cafferty described the plans for a new optimisation study of the FIRST spacecraft by JPL/ESA.
- An initial meeting is arranged for 21, 22 June at ESTEC. The scope of the study is not clear yet. It might cover just the telescope or it could be extended to cover the complete system. If the remit is to look at the whole system, possibilities would include a temperature of around 60 K for the telescope and cryostat shell, an optical bench at 2 K with a shield at around 6 K, and a 1000-litre dewar for 4.5 year lifetime.

## Status of SPIRE:

- The intensity beam-divider FTS option has been selected.
- The detailed optical design and layout are now available.
- The division of focal plane between the three FIRST instruments still not finalised - SPIRE may be able to provide some extra space for HIFI.
- An option of extending FTS range to 150  $\mu\text{m}$  is being studied – the detector aspects were to be addressed during this meeting.
- A technical meeting with the ESTEC project took place on March 15. Delays in the detector evaluation programme were noted by ESA
- A three-phase PDR plan has been defined:

Phase 1:	July 7-9 at RAL
Phase 2:	Sept. 29, 30 and October 1 at Saclay
Phase 3:	March 2000 following detector selection

The three detector options will undergo PDR in Phase 2 in September, but focal plane designs to be included in Phase 1 in July. Of particular importance were the mechanical and thermal design and interfaces and the cryoharness requirements.

**Dates of future meetings:** Dates were agreed as follows

Meeting	Venue	Date
Detector Array Group	Saclay	September 28
PDR Phase 2	Saclay	September 29, 30, October 1
PDR Phase 3	TBD	March 2000 (TBC)
CDR	TBD (probably RAL)	TBD - not long after PDR Phase 3

## **2 Update on SPIRE instrument design**

Bruce Swinyard presented a summary of the current SPIRE instrument design (see viewgraphs)

The following points were noted during Bruce's talk:

(i) Headroom: More headroom would be very helpful for SPIRE. This could be an outcome of the JPL/ESA system study.

(ii) Wavelength bands: These two shorter wavelength band centres were likely to be changed to 225 and 333  $\mu\text{m}$ . These small changes to the filters would have little or no impact on the design of the rest of the system.

(iii) Mechanical design: Concerns were expressed concerning the over-constrained FPU mechanical design and the possible impact on optical alignment tolerances. The FPU integration would be very complicated.

(iv) Impact of possible low-temperature optical bench interface: With a 2-K interface optical bench interface, the mechanical design would be greatly simplified. Implementing the JFET box for the feedhorn option would be tricky in the event of a 2-K optical bench.

(v) Thermal straps: It might be easier if they came from the side rather than from below.

(vi) Beam modelling: Results showed that the beam size on the sky was very similar for the feedhorn and filled array options.

(vii) Possibility of going to 150  $\mu\text{m}$  with the spectrometer: The performance of the FTS beam divider was just consistent with this, but there were questions about detector arrays; costs of feedhorns etc. (to be addressed splinter session later in this meeting)

## **3 Status of actions from previous meetings**

Ken King reviewed the open actions from previous meetings. An updated summary, including further actions generated at this meeting, is given in Section 13 below.

## **4 PDR plans**

Matt Griffin reviewed the aims and format of the July PDR Phase 1 (see viewgraphs), based on the note that was circulated to all Co-Is and institute project managers on March 31. The Review Board members would be: Douwe Beintema; Paul Harvey; Derek Martin; Thomas Passvogel; Guy Serra (TBC). The PDR was the most important forthcoming event for the SPIRE consortium. The Review Board is certain to take a strong interest in the array programme and its impact on the FPU design, and it would be very important to present a convincing preliminary design for the focal plane array modules.

See also Section 10 for further discussion of PDR readiness.

## 5 Array group progress reports

### 5.1 CEA arrays

Louis Rodriguez presented this progress report - see viewgraphs for details.

Points noted during Louis's presentation:

(i) Thermometers: three kinds with different shapes made on same wafer have been tested. with different non-thermal effects observed for the different shapes. Harvey Moseley suggested that this could be due to their different volumes (and consequent different power densities).

(ii) Mechanical/thermal interfaces: A problem was the thermal decoupling of detector array and readout circuit. The requirements were to have low readout capacitance - dictating that the follower be as close as possible to the detector while keeping the readout at 2 K. The original scheme involved isolation by a Si membrane - vibration tests will be done on this configuration in June. Another way to solve the problem is being investigated: incorporating the readout follower in the MUX at 300 mK with a second CMOS operational amplification stage at 2 K (which doesn't need to be so close to the MUX). This is also compatible with differential wiring to warm electronics, perhaps making the BAU unnecessary.

(iii) SPIRE mechanical design: The current mechanical design concept does not have 300-mK shield. The baseline for SPIRE is that a 300 mK shield be included with bandpass and blocking filter fitted to it. The photometric necessity of having these filters at 300-mK is to be confirmed, but suppression of stray light will probably necessitate having a 300-mK shield anyway.

(iv) Electronics readout: The new CMOS transistors are very sensitive to ESD - care is therefore essential in handling and operation.

(v) Schedule: The schedule has moved by about 1 month since last time. Assuming that the QMW BACUS is ready by the beginning of June, testing of a  $16^2$  array can be done at QMW in week 22.

### 5.2 GSFC/NIST arrays

Harvey Moseley presented this progress report - see viewgraphs for details.

Points noted during Harvey's presentation:

(i) Noise modelling: A 2-pole thermal model fits the data. Ways of minimising the extra heat capacities would be investigated. Below 1 Hz the  $1/f$  noise is probably due to warm electronics. 1-2 Hz is reasonable projection of  $1/f$  performance for SPIRE.

(ii) Schedule: Assuming a 2-month testing period at Goddard, delivery of the GSFC BACUS system to QMW would be around the end of October.

### 5.3 JPL/Caltech arrays

This report was presented by Jamie Bock, Faiz Rahman (electronics architecture), Hien Nguyen (array testbed) and Jason Glenn (BOLOCAM status). Bruce Swinyard also reported on initial testing of the prototype JPL horn array at RAL. See viewgraphs for details of all presentations.

Points raised during this presentation:

- (i) Laurent Vigroux pointed out that the factor of 2.7 for the theoretical advantage in mapping speed for filled arrays would need to be modified to take into account observing overheads (e.g., telescope turnaround for slow scanning observations).
- (ii) Further testing of the prototype horns was planned at RAL, including measurements at the correct wavelength, incorporation of a beam monitor to correct for laser power output variations, and use of a rotating stage for the horn.

## **5.4 QMW BACUS system**

This report was presented by Peter Hargrave.

Points noted during Peter's presentation:

- (i) Initial tests on the larger area illuminators provide by GSFC showed a thermal time constant of around 0.5 sec. This would be a bit too slow for the photometer calibrator, but no problem for the spectrometer calibrator.
- (ii) The QMW BACUS filters are being measured for IR-UV light leaks
- (iii) The JPL and Goddard groups believed it to be important to be able to look out of the dewar for some in-house testing. It was therefore important for QMW to provide filters to allow this (issue discussed in Array Test Plan splinter later in the meeting)
- (iv) Optical crosstalk cannot be tested with uniform illumination, and was not something for which BACUS was well suited. Any results would be characteristic of the optics rather than the detectors.

## **6 PDR Dry runs**

### **6.1 CEA arrays**

This was presented by Louis Rodriguez and Yannick Le-Pennec - see viewgraphs for details.

Points raised in this presentation:

- (i) The full SPIRE field of view would be built up using 16 x 16 arrays
- (ii) Arrays are to be vibration tested in June
- (iii) Crosstalk comes in only at the MUX level and can be eliminated by voltage guard wires.
- (iv) The geometrical filling factor for ionising radiation is below 30% (exact figure is TBC)
- (v) For submillimetre radiation, the pixel efficiency (sensitive area/occupied area) was 0.91 for 350  $\mu\text{m}$  and 0.95 for 500  $\mu\text{m}$ .

(vi) SAp thought it more efficient to adopt their own array module mechanical design rather than to use the design concept being used by JPL and GSFC.

(vii) For the termination of the Kevlar wires, a scheme suggested by Lionel Duband was being considered.

(viii) A mechanical FEA analysis on the array mounting concept is being done.

(ix) The cables to the 4-K level can be as long as required

(x) To minimise cost and risk, CEA were considering using the same arrays at 250  $\mu\text{m}$  and 350  $\mu\text{m}$ , so oversampling the PSF at 350  $\mu\text{m}$ .

**Action: All array groups to quantify and tabulate geometrical filling factor for ionising radiation for 225, 350 and 500  $\mu\text{m}$  arrays.**

**Action: GSFC and CEA to specify pixel filling factor (fraction of total array area which is not sensitive to submm radiation) for their arrays (225, 333 and 500  $\mu\text{m}$ )**

## 6.2 GSFC/NIST arrays

This was presented by George Voellmer - see viewgraphs for details.

Points raised during this presentation:

(i) The suspended mass at 300 mK is about 300 gm.

## 6.3 JPL/Caltech arrays

This was presented by Jamie Bock (overview); Dustin Crumb (Focal Plane Structure); Anthony Turner (Array Fabrication); Srinivasan Sethuraman (JFETs); Victor Hristov (Signal Processing Electronics); and Terry Cafferty (Thermal Model)

Points raised during this presentation:

(i) The estimated NEFDs were somewhat better than in the proposal. This was probably due to slightly different assumptions being made about overheads etc.

(ii) With the feedhorn option, the data rate is not a problem for SPIRE. This could make operation in parallel with PACS easier to implement.

(iii) The feedhorn array design for the FTS still needs to be optimised.

(iv) It will probably be necessary to include a 2-K structure also. This should not be a major problem.

(v) It is not known whether U401 JFETs are on the ESA parts list. Note: there is already an action on all groups to provide a list of all parts that they would like to use which are not on the ESA list (or whose status is uncertain).

**Action: Matt Griffin to provide Jamie Bock with the latest sensitivity models for SPIRE and discuss the assumptions and methods.**

**Action: All array groups provide list of non-standard parts that they may wish to use. This will then be provided to ESA for comment.**

## **7 Report from Co-Is' meeting**

Matt Griffin reported on the conclusions of the Co-Is' meeting held on the evening of May 20.

Topics discussed had included: (i) policy in the event of insufficient test data being available at selection time; (ii) agreement of list of suitable people to act as independent advisers; (iii) stance to be adopted concerning the possibility of radical change to cryostat thermal design.

(i) The continuing hard work and dedication of those involved in the array programme is recognised and applauded. At the same time, it is clear that the programme is extremely ambitious and that the schedule has no margin. The likelihood is therefore that not all planned tests would be successfully completed and results understood by the time for selection. It will not be possible to predict how this would occur. The major participants will all retain scientific interest in the mission regardless of the outcome, and are all committed to flying the best available and fundable detector technology that we can rely on. It is important that the decision be based on consensus. The choice will be made by the selection team drawn from the consortium, but very close attention will be paid to the views of the independent advisers who will be invited to the selection meeting.

(ii) A list of names for the independent advisers was agreed, and the people will be contacted by Matt Griffin.

(iii) The possibility of a solid 2-K environment for the FPU was very attractive in principle, and would probably bring a substantial reduction in overall cost and risk over the lifetime of the project. But practical and programmatic considerations must be kept in mind - any solution which involved a major delay would not be acceptable. The envisaged meeting in the third week of June should help to clarify the situation.

## **8 Detector Selection Criteria**

Matt Griffin presented a summary of the document *Detector array selection criteria for SPIRE (Draft 2)* which he had circulated on 14 May - see viewgraphs (and Annex TBD for a copy of the note itself). He emphasised the importance of this note, which would be the main set of guidelines for the array selection process. It was vital that it be carefully reviewed by all interested parties.

Points raised during this presentation:

(i) It would be important to revise the values of the parameter  $\alpha$  (which characterises the mapping speed difference between filled arrays and feedhorn arrays) to take into account observing modes and overheads.

(ii) Other important factors not mentioned in the note were:

- Risk
- Heritage
- Implications of telescope background being higher or lower than the designed value

- Implications for consortium resources
- Long-term stability of the overall system (perhaps some tests could be done in BACUS)

(iii) Filled arrays should have an advantage over feedhorn arrays for extraction of information at low spatial frequencies.

**Action: Array groups and others to comment on the existing draft in as much detail as possible by June 4.**

**Action: Matt Griffin to produce revised draft which will be distributed as part of PDR documentation**

## 9 Splinter meetings

See reports in Section 11 below.

## 10 PDR readiness

One of the main purposes of the meeting was to have a dry run of the PDR presentations and to use the opportunity to make mistakes and omissions now rather than at the PDR.

Ken King and Bruce Swinyard made some general comments about the PDR dry run presentations, and there was some discussion of what needed to be done.

**Design and technical description:** Some areas were adequately covered, but others were not properly addressed. For example: Operations - OK in the JPL case but no information from others; requirements on other subsystems (e.g., data rate) need to be specified; risk factors and heritage needed to be addressed; no schedules were given; no qualification and testing plans were given.

**Approach:** In some cases the presentations looked like a status report on test detectors instead of description of flight model design.

**Format: It was important to have a uniform format for the presentations and to address explicitly all of the issues laid out in the PDR Plan document.**

**Development plan:** There was a good deal of uncertainty over what should appear in the Development Plans for the July PDR. The most suitable approach might be to present a high-level overview in July and leave the detailed description to the PDR Phase 2 in September, when the detector options would be more completely reviewed.

**Action: Ken King to specify what is needed for the development plan**

**Action: Bruce Swinyard to review list of headings for July PDR viewgraphs/viewgraph sequences and provide Powerpoint template to all subsystem groups**

**Array size to be presented at PDR (4 x 4 or 4 x 8):**  
This was the subject of some debate.

- The optical design is consistent with a 4 x 8 field.

- The current JPL design is based on 4 x 8, which is compatible with data rate and other resource budgets. To present a 4 x 4 option would require a lot of extra work.
- For the filled array options, there were legitimate doubts as to whether the 4 x 8 option was over-ambitious and whether it could be made compatible with spacecraft and consortium resources. Perhaps presenting 4 x 8 for the feedhorn and 4 x 4 for the filled array options would be wiser.
- There was a risk that if 4 x 4 were presented, then spacecraft resources could become fixed for this option and it might not be feasible to have a 4 x 8 field of view in the end.

**Conclusion:** We should:

- Present 4 x 8 as the goal to which we are designing - the compatibility with internal constraints and spacecraft resources is TBC.
- Make it clear that we can meet spec and spacecraft resources with 4 x 4
- Emphasise that reverting to 4 x 4 for a filled array option would not be a de-scope - we are designing for the goal and will at least meet the requirement.

**Action: Ken King to specify what is needed for the development plan**

**Action: Bruce Swinyard to review list of headings for PDR presentations**

## 11 Splinter meeting reports

To be included.

## 12 Simulations

Matt Griffin gave a presentation compiled by Seb Oliver outlining the status of simulation work at IC - see viewgraphs for details.

Points raised during this presentation

(i) There was some discussion about various technical points and about the relative merits of filled and feedhorn arrays. It was clear that there is still no consensus on a number of important points, and that the IC results are not in agreement with some aspects of the Saclay simulation results. It is vital that these issues be addressed and clarified soon as they are vital for the decision on which array technology to fly.

(ii) For the moment, the main purpose of the simulation work was to elucidate the differences in performance of the feedhorn and filled array options. There were many other important aspects which would come to the fore after array selection, but attention should be focussed on the most urgent question for now: to identify and quantify any significant differences in the scientific capabilities of the array options.

**Action: Matt Griffin to distribute electronic version of Seb's viewgraph package to all participants**

**Action: All interested parties (particularly the array groups) to comment on Seb's presentation or any other aspect of SPIRE simulation work, to MJG as soon as possible**

**Action: Laurent Vigroux to organise a meeting on simulations before PDR in July (ideal participants: Oliver, Vigroux, Griffin, Gear, Aussel, representatives of Caltech and GSFC).**

## **13 Summary of the meeting and actions**

### **13.1 Meeting summary**

There was not time for this at the meeting and the chairman was blue in the face already. The following points are clear however:

- A great deal of work needs to be done to prepare for PDR.
- The schedule for the array evaluation and test plan remains very optimistic.
- It is vital to work towards an agreed approach to simulations.

### **13.2 Summary of actions**

A summary of new actions arising from this meeting is given in the table below.

**SPIRE DETECTOR ARRAY GROUP MEETING, MAY 20, 21 1999**

**ACTIONS FROM THE MAIN MEETING**

<b>Action number</b>	<b>Description</b>	<b>Responsible</b>	<b>Due date</b>	<b>Status</b>
AI-DET-0000-44	All array groups to quantify and tabulate geometrical filling factor for ionising radiation (fraction of pixel area that is can be struck) for 225, 333 and 500 $\mu\text{m}$ arrays.	Bock, Moseley, Rodriguez	June 14	Open
AI-DET-0000-45	GSFC and CEA to specify array filling factor (fraction of total array area which is sensitive to submm radiation) for their arrays (225, 333 and 500 $\mu\text{m}$ ).	Bock, Moseley	June 14	Open
AI-DET-0000-46	Provide Jamie Bock with the latest sensitivity models for SPIRE and discuss the assumptions and methods.	Griffin	May 31	Open
AI-DET-0000-47	Provide list of non-standard parts that they may wish to use. This will then be provided to ESA for comment.	Bock, Moseley, Augueres	June 20	Open
AI-DET-0000-48	Comment on the existing draft of the <i>Array Selection Criteria</i> document in as much detail as possible.	Bock, Moseley, Vigroux, others.	June 4	Open
AI-DET-0000-49	Produce revised draft of <i>Array Selection Criteria</i> document which will be distributed as part of PDR documentation	Griffin	June 14	Open
AI-DET-0000-50	Specify what is needed for the development plan.	King	May 31	Open
AI-DET-0000-51	Review list of headings for July PDR viewgraphs/viewgraph sequences and provide Powerpoint template to all subsystem groups.	Swinyard	May 31	Open
AI-DET-0000-52	Distribute electronic version of Seb's viewgraph package to all participants.	Griffin	May 27	Open
AI-DET-0000-53	Comment on Seb's presentation or any other aspect of SPIRE simulation work.	Bock, Moseley, Vigroux, others.	June 10	Open
AI-DET-0000-54	Organise a meeting on simulations before the PDR in July (ideal participants: Oliver, Vigroux, Griffin, Gear, Aussel, representatives of Caltech and GSFC).	Vigroux	June 30	Open
<b>ACTIONS FROM THE SPLINTER MEETINGS - to be compiled</b>				